Subchapter 3: Tributary Dams/Hydropower

The states of Washington and Oregon are developing parallel and coordinated efforts to restore wild steelhead in the Lower Columbia Steelhead Conservation Initiative (LCSCI) to healthy levels. Healthy stocks are as defined by WDF et al. (1993). This Subchapter reflects the efforts of a team working on the hydropower and dams component.

In general, as mentioned elsewhere in this document, restoration measures include analysis and planning, implementation, and monitoring. As watershed analysis and planning are important steps in restoration, and in identifying projects that will have the greatest benefits to fish because of feasibility and effectiveness. Implementation will requires considerable commitment. Implementation monitoring will be performed to ensure that priority measures are implemented according as planned. Biological trend and effectiveness monitoring will be performed to determine if steelhead stocks are responding as expected to restoration measures.

In discussions with Oregon staff working on similar conservation issues for the Steelhead Supplement to the Oregon Plan in the Lower Columbia ESU, little overlap was envisioned. For the most part, steelhead on the two sides of the Columbia River share the river as a migratory route, but most of their freshwater lives are spent in the tributary streams. There is some level of straying, but it is thought to generally be low. Consequently, measures to protect or restore wild steelhead, particularly as related to dams and hydroelectric projects in one state will have only long-term effects on stocks in the other state. The exception to this generalization is Bonneville Dam, which impedes stocks in the upper part of the Lower Columbia ESU in both states.

This portion of the LCSCI discusses dams and hydroelectric projects. Dams in the Washington portion of the Lower Columbia Steelhead ESU are listed by watershed and Water Resource Inventory Area (WRIA) in Table 1.

Table 1			
WRIA	**RIVER**	**PROJECT**	**PROJECT OWNER**
26	**Cowlitz**	**Cowlitz Hydroelectric Project (FERC No. 2016) Barrier, Mayfield and Mossyrock Dams**	**Tacoma Public Utilities**
26	**Cowlitz**	**Cowlitz Falls Dam (FERC No. 2833)**	**Lewis Co PUD**
26	**Mill Creek**	**Mill Creek Hydroelectric Project (FERC No. 4949)**	**Lewis County PUD**
26	**Toutle**	**Sediment Retention Dam**	**US Army Corps**
27	**N. Fk. Lewis**	**Merwin (FERC no. 935), Yale (FERC No. 2071), Swift No. 1 (FERC No. 2111)**	**PacifiCorp**
27	**N. Fk. Lewis**	**Swift No. 2**	**Cowlitz County PUD**
27	**E. Fk Lewis**	**Bigg's Creek (FERC No. 9044)**	**Fred Pickering**
28	**Washougal**		
29	**Wind**	**Trout Creek Dam**	**Gifford Pinchot Forest**

Factors for decline, dams, and hydroelectric projects

Factors for decline have been identified in Chapter 7 and in earlier subchapters of Chapter 14. For the purposes of this subchapter they have been categorized as:

A. Water Quality
B. Physical Habitat
C. Water Quantity, Fish Passage, and Fish Screening
D. Fish Management

Dams and hydroelectric projects are associated with a number of factors for decline. Each dam and hydroelectric project is different and thus the range and importance of individual factors for decline among them vary. The following discussion focuses on how each factor for decline affects steelhead and other fish. The magnitudes of effects and proposed restoration measures will be further discussed under each dam, project, or set of projects.

While dams and hydropower projects offer society certain beneficial uses, they have significantly altered natural river systems in the Northwest. In Washington's part of the Lower Columbia Steelhead ESU the watershed area that is upstream of dams (not including the Toutle sediment retention dam) is about 58% of the total. There are two major dam complexes, one on the Cowlitz River and another on the North Fork of the Lewis River. These presently block anadromous fish and have caused a number of other impacts to steelhead. The effects of such facilities on anadromous and resident fish have been well documented in many basins and cumulative losses to wild steelhead are substantial. Dam construction and operation, in many cases, have stressed aquatic systems, and the fish that reside and migrate in them, beyond their ability to adapt.

Hydropower projects and storage dams affect fish and rivers in many ways. The contribution of dams to each of the biological factors of decline addressed under Water Quality; Physical Habitat; Fish Management; and Water Quantity, Fish Passage, and Fish Screening is discussed specifically below. Any dam can contribute to several factors of decline, but not all dams have all these impacts. Below is a general overview of the negative ecological impacts dams can cause.

A. Dams alter river flow regimes (see C-I in Tables 4 and 7) by diverting for power or other purposes water that would otherwise contribute to healthy instream ecosystems. In the worst cases, bypass reaches below dams are completely de-watered. Some original (state and federal) licenses issued to existing hydropower projects did not require flow to the bypass reach. This fact has resulted in poor water quality (see A in Tables 4 and 7), passage barriers (see C-II), stranding, and loss of rearing, holding and spawning habitat (see C-IV).

   Projects where effect occurs: Swift #2, Merwin, Cowlitz (Mayfield, Mossyrock)
   Affected reaches: Downstream from powerhouse and bypass reach

B. Dams block rivers. They alter or prevent the flow of plants and nutrients, on which fish and their prey depend, and impede the migration of fish (see C-II in Tables 4 and 7).

Upstream habitat is either completely cut off or underutilized, unless passage at the dam and through the bypass reach is very good. While fish passage structures – when present – enable some fish to pass around a dam, these species/ESUs are still jeopardized by the cumulative impact of passing multiple dams. The fish population decreases with each dam passing. Some dams have no fish passage structures at all. Barging and trucking of fish around dams can increase the risk of disease, stress-induced mortality, predation, and diminishes homing abilities.

Projects where effects occur: Cowlitz, Lewis River projects, (Trout Creek)
Affected reaches: Dams

C. Dams with reservoirs decrease water velocities and/or cause a confusing flow pattern that results in fish being lost or delayed (see C-I, C-II, C-IV in Tables 4 and 7) if fish get into the reservoirs. Steelhead and other anadromous salmonids depend on high flows to facilitate down river migration by smolts and guide their return upstream to spawning grounds as adults.

Projects where effects occur: Cowlitz, Cowlitz Falls, Lewis River projects, Trout Creek
Affected reach: Reservoir

D. Reservoirs inundate riverine habitat (see B-VII and C-IV in Tables 4 and 7). The creation of reservoirs results in a permanent loss of spawning habitat in the affected reaches, diminishes the quality of habitat for juvenile rearing and cover, and alters macroinvertebrate communities on which steelhead depend for food.

Projects where effects occur: Cowlitz, Cowlitz Falls, Lewis River projects, Trout Creek
Affected reach: Reservoir

E. Dams can alter water temperatures (see A-I in Tables 4 and 7). Factors such as reservoir size, retention rate, and type of outlet structure affect whether water releases are warmer or cooler. Salmon and other fish are sensitive to non-natural temperature regimes, which can affect negatively native populations.

Projects where effects occur: Cowlitz, Cowlitz Falls, Trout Creek
Affected reaches: Downstream from powerhouse, bypass reach, pool or reservoir

F. Dams can alter the timing of flows (see C-I in Tables 4 and 7). By withholding and then releasing water to generate power for peak demand periods, or for other extractive uses, dams cause extreme variations in in-stream and riparian habitat conditions downstream. Conditions alternate from low water to great surges of water, a situation which can strand fish and erode soil and vegetation. These irregular releases destroy natural seasonal flow variations that help trigger growth and reproduction cycles. Unnatural seasonal fluctuations also often conflict with seasonal habitat needs of aquatic organisms both upstream and downstream.

Projects where effects occur: Cowlitz, Lewis River projects
Affected reaches: Downstream from powerhouse, bypass reach

G. Dams can fluctuate reservoir levels (see B-I and C-I in Tables 4 and 7). Peaking power operations can cause dramatic changes in water levels, which degrade upstream shorelines and disturb fish and bottom dwelling organisms.

Projects where effects occur: Cowlitz, Cowlitz Falls, Lewis River projects
Affected reach: Reservoir

H. Dams can decrease oxygen levels (see A-III in Tables 4 and 7) in reservoir waters and disturb the balance of other natural gases downstream. When oxygen-deprived water is released from behind a dam, it kills fish and vegetation downstream. In addition, the spilling of large amounts of water from big dams contributes to super-saturation of nitrogen (see A-IV) in the water immediately downstream of the dam, which can also kill fish.

Projects where effects occur: Cowlitz, Cowlitz Falls, Lewis River projects
Affected reaches: Below powerhouse, bypass reach, reservoir

I. Dams can hold back silt, debris, and nutrients (see A-II in Tables 4 and 7). By slowing flows, dams allow silt (see A-II and B-III) to collect on river bottoms and bury habitat for fish spawning and benthic organisms, on which fish feed. Silt trapped above dams accumulates heavy metals and other pollutants (see A-VII). Gravel, logs and other debris (see B-II, B-III, B-IV) are also trapped by dams, making them unavailable for downstream food and habitat.

Projects where effects occur: Cowlitz, Cowlitz Falls, Lewis River projects, Trout Creek
Affected reaches: Reservoir, bypass reach, below powerhouse

J. Hydropower dams kill (see B-VII in Tables 4 and 7) and injure fish as they pass through turbines, if adequate screening is absent (see C-III). Fish are drawn into power turbines, where they are subject to striking turbine blades and hydraulic shear. Fish are also drawn into diversion channels if not properly screened.

Projects where effects occur: Cowlitz, Cowlitz Falls, Lewis River projects, Trout Creek
Affected reaches: Dam, reach below powerhouse

K. Dams can increase risk of predation (see A-V and D-III in Tables 4 and 7). Warm, murky reservoirs often favor naturally occurring species of predators. In addition, passage through fish ladders and turbines injure or stun fish, and concentrate them, making them easy prey for avian hunters, such as gulls, herons and eagles. Dams can also lead to increased fishing pressure with resultant hooking mortality and harvest.

Projects where effects occur: Cowlitz, Cowlitz Falls, Lewis River projects, Trout Creek
Affected reaches: Reservoir, reach below powerhouse, bypass reach

L. Mitigation for dams in the form of hatchery production (see D-II in Tables 4 and 7) has resulted in genetic, harvest (see D-I), and disease (see A-V) impacts. Toxic chemicals (see A-VII) used in hatchery practices can be released to the stream.

Projects where effects occur: Cowlitz, Lewis River projects
Affected reaches: Reach(es) below hatchery

Mitigation Opportunities and Conservation Measures at Specific Dams and Hydroelectric Projects

While the existence of dams typically alters dramatically the functions of a natural river system, in most circumstances, changes to the operation of the dam can yield significant benefits to fish. Such changes include **improved base flows**, **less disruptive water release schedules**, and **fish passage** mechanisms. Management measures range from installing and upgrading fish **screens** and ladders to implementing minimum in-stream flow releases. Gradual ramping of reservoir levels and regulation of water temperature and dissolved oxygen and other gas levels also help mitigate the impacts of dams on salmon. Off-site measures may be needed to mitigate for unavoidable losses, such as lost riparian and lost free-flowing habitat. In extreme cases, dam removal and site restoration may be the most feasible option for reducing fish losses associated with a project.

Phase 1 Conservation Actions

Modifying the operations at federally-licensed hydroelectric projects must be done through the Federal Energy Regulatory Commission (FERC). FERC is the regulatory body which oversees the construction and operation of hydroelectric projects. FERC issues license for hydroelectric projects for a period of thirty to a maximum of 50 years. When these licenses expire, a new license is required and the licensee is required to consult with resource agencies, Tribes and the public. The licensee is required to submit a final license application two years before the actual expiration date of the license. License expiration dates for hydroelectric projects in the LCSCI area are shown in Table 2.

New license proceedings offer an excellent opportunity to implement environmental improvements at a project. The proposed continued operation of the project must be evaluated in light of current laws and regulations (most of today's environmental laws and regulations did not exist at the time many projects were constructed). Pursuant to Section 10(j) of the Federal Power Act, as amended by the Electric Consumers Protection Act, state and federal resource agencies (e.g., U.S. Fish and Wildlife and National Marine Fisheries Service, may recommend that certain fish and wildlife protection measures be included in a new license.

Table 2			
RIVER	**PROJECT**	**LICENSE EXPIRATION DATE**	**PROJECT OWNER**
Cowlitz	Cowlitz Hydroelectric Project Barrier, Mayfield and Mossyrock Dams (FERC No. 2016)	2001	Tacoma Public Utilities
Mill Creek	Mill Creek Hydroelectric Project (FERC No. 4949)	Exempt Project	Lewis County PUD
N. Fk. Lewis	Swift No. 1 (FERC No. 2111)	2006	PacifiCorp
N. Fk. Lewis	Swift No. 2 (FERC No. 2113)	2006	Cowlitz County PUD
N. Fk. Lewis	Yale Dam (FERC No. 2071)	2001	
N. Fk. Lewis	Merwin (FERC 935)	2009	
Cowlitz	Cowlitz Falls (FERC No. 2833)	2036	Lewis County PUD

FERC is required to give these recommendations due consideration and must adopt them unless FERC finds them inconsistent with the Federal Power Act. Under Section 10(a) of the Federal Power Act, FERC must give equal consideration to power and non-power values. Under Section 4(e), FERC must include measures prescribed the agency responsible for managing the a federal reservation (e.g. a national forest) upon which part of a project resides. Finally, under Section 18, both the Department of Interior and the Department of Commerce may prescribe up and downstream fish passage measures at a hydroelectric project.These prescriptions are mandatory.

In both the Cowlitz and Lewis river basins, major relicensing proceedings area underway and both federal and state resource agencies are addressing the limiting factors caused by these projects. Consultation between the agencies and the licensees is occurring. Studies are being completed which will provide the information required to design the best restoration actions. The FERC licensing process can be cumbersome and subject to delay, but it is an established process for addressing resource problems.

FERC generally preempts state laws and regulations. For example, hydroelectric licensees are not required to obtain hydraulic project approvals (HPAs) from the state Department of Fish and Wildlife. One exception is that the state water pollution control agency (in Washington, the State Department of Ecology) may require mandatory conditions on hydroelectric projects via issuance of a water quality certification pursuant to Section 401 of the federal Clean Water Act. The state has broad discretion to require measures which are necessary to sustain a designated use of a water body (e.g., salmonid migration, rearing, spawning and harvesting). The state also may object to a project which affects coastal resources under the state's federally-approved Coastal Zone Management Program pursuant to the federal Coastal Zone Management Act.

The clusters of hydroelectric projects on the Cowlitz and Lewis rivers have created a number of factors for decline. During FERC project relicensing, state and federal fish and wildlife agencies will recommend and/or require measures to mitigate the factors for decline attributable to these projects. For each group of projects, likely recommendations/requirements are listed in Table 3 in order of the priority of the factor of decline. Dam removal is being considered as a restoration measure for wild salmonids in some basins, but no dam removal is anticipated in the Lewis and Cowlitz basins, so the measures are intended as mitigation for ongoing impacts of projects.

Table 3		
Factor(s) for decline	**Probable type of mitigation recommendation**	**Prospects for success**
1. Downstream passage for juvenile steelhead (C-II & C-III in Table 4)	Smolt collection facilities at multiple locations and transport and release of fish below dams	Difficult, but improving, and juvenile steelhead are the easiest of anadromous salmonids to pass downstream
2. Downstream passage for juvenile steelhead (C-II & C-III in Table 4)	Improve screening of intakes in conjunction with smolt collection facilities	Effective screening is very expensive at large intakes. Much work at many projects has led to improvements in collection efficiency, but major problems remain.
3. Upstream passage of adult steelhead (C-II & C-III in Table 4)	Trap-and-haul might be the most effective measure to move fish around entire complex of dams and reservoirs	Handling mortality can be high.
4. Upstream passage of adult salmon (A-VIII in Table 4) to provide carcasses for watershed nutrients	Trap-and-haul might be the most effective measure to move fish around entire complex of dams and reservoirs.	Handling mortality can be high, but carcasses can be distributed with minimal loss of effectiveness.
5. Upstream passage of adult salmon (A-VIII in Table 4) to provide carcasses for watershed nutrients	Transport and distribute salmon carcasses from hatcheries to tributaries.	High feasibility, depending on access and personnel availability, but some flexibility.
6. Elimination of stream habitat as a result of inundation and conversion from lotic to lentic has resulted in loss of production of steelhead from those inundated stream reaches (B-VII in Table 4)	Hatchery production was the mitigation/replacement measure for this impact under existing FERC licenses. Emphasis on replacement of inundated habitat with hatchery production will continue. That effort will include upgrading to achieve mitigation obligations, while managing hatchery fish to minimize adverse effects on wild population genetics and wild fish production.	High feasibility, limited by degree of cooperation and commitment to objectives by utilities.
7. Flow management, both level of flow and timing and rate of change of flow (ramping and flow continuation), can affect steelhead in a variety of ways (C-I in Table 4)	Instream flows and ramping rates are recommended by time of year and time of day. Only one project (Swift No. 2) has no instream flows now. Others may require modification.	Effectiveness of flow management is variable, with some aspects of dam impacts mitigable, but other long-term impacts on channel structure less easily mitigated. The long-term effects of storage dams control productivity and ecology

		of the entire river system and these effects are more difficult to mitigate with instream flow prescriptions.
8. Gas supersaturation, caused by plunging water over a spillway, causes mortality of fish downstream. Spill, which produces gas supersaturation, is an infrequent event at the Cowlitz and Lewis projects, but is more common on the mainstem Columbia projects, where it is a downstream passage measure.	Dam spillway modification to flip spilling water into the air before it hits the water can reduce gas supersaturation.	Highly effective but expensive, considering the rarity of spill.
Downstream passage through reservoirs	Increase flow rate through reservoirs and manage stage/rule curve to avoid stranding	

Ongoing FERC licensing proceedings:

Cowlitz Project: Tacoma Public Utilities will be submitting a new license application for the Cowlitz Project by the end of 1999. The Utility is now consulting with agencies and intervenor groups and conducting studies to provide information on such issues as fish passage, instream flows and other potential enhancement measures. These studies are being conducted using the Ecosystem Diagnostic Treatment method. The Utility has proposed an applicant-prepared environmental assessment as a means of streamlining the licensing process (as opposed to waiting for FERC or a FERC contractor to prepare an EA, or EIS).

Yale Project: PacifiCorp has begun consultation on the its Lewis River Projects. The Yale Project license expires in 2001, the Swift Projects in 2006 and Merwin in 2009. In early consultation, resource agencies expressed a desire to address all projects in a comprehensive manner. PacifiCorp did not consent to opening up the licenses for all of its projects, but did agree to perform a watershed analysis which would address the cumulative impacts of all of its projects (including Swift #2, which is owned by Cowlitz County PUD). PacifiCorp also has expressed a willingness to implement mitigation prior to the expiration of its licenses for Swift No. 1 and Merwin Dam if a settlement agreement can be achieved. This would result in getting environmental improvements in place sooner than later and also would expedite the licensing of the Merwin Project when its license expires in 2009. As for Swift #2, which is owned by Cowlitz County PUD, the PUD has yet to indicate that it would be willing to implement environmental improvements prior to the expiration of its license. Cowlitz County PUD and PacifiCorp are working on a Memorandum of Understanding on the respective utilities' goals and responsibilities.

The Cowlitz Falls Project license does not expire until 2036. However, there are active studies underway to evaluate fish passage efficiency at the project (see description of Cowlitz Falls project).

Mill Creek is an exempt project and hence is subject to state regulations.

Hydro/dam project-specific measures to mitigate the related impacts on anadromous fish are proposed in the sections that follow.

WDFW staff are working with PacifiCorp and others on the Lewis River basin Watershed Analysis and Integrated Land Management (ILM) process, and with TPU and others in the Ecosystem Diagnostic and Treatment (EDT) process for the Cowlitz basin. Watershed Analysis and EDT are associated with relicensing efforts for part of the group of hydroelectric projects in the respective basins. Both efforts are longer and slower than the fast-track steelhead plan, and neither is exclusively a steelhead plan, but the LCSCI can benefit from work done by these groups.

Wind River (WRIA 29)

Hemlock Dam

Location: Trout Creek
Owner: Gifford Pinchot National Forest
Description of dam: Hemlock Dam was built in 1936 by USDA Forest Service to provide electricity for the Wind River District Office and Nursery. After hydropower generation was discontinued, the dam remained as a source for nursery irrigation water. About 50% of native steelhead production in the Wind River basin came from Trout Creek above the dam. A 1987 study by Dr. Jack Orsborn (WSU) identified inadequate attraction flow for passage as the major impact of this dam. The reservoir was used as a source of water for the Wind River Nursery up to 1977, when the Wind River Nursery was closed. A proposed land swap with Skamania County may involve transferring ownership of the dam and reservoir to the county. The reservoir currently provides a reservoir for recreational activities. The county's objectives for the dam and pond are uncertain; the county might not fund dam removal nor maintenance.

Factors for decline:

passage - This is by far the largest impact of Hemlock Dam. The dam was built with a fish ladder, but its effectiveness was low. (C-II)
temperature (A-I)
sediment (A-II)
substrate (B-III)
screening (C-III)

Phase 1 Measure: Improve fish ladder attraction flow and improve screen

Factors for decline the measure will improve:

adult steelhead upstream passage (C-II)
steelhead smolt outmigration
screening (C-III)

Additional attraction flow was created for the fish ladder. A fish ladder wall extension was created to direct additional attraction flow. Wasteflow from nursery waterlines is being routed back to Hemlock Reservoir. Screening for the intake is being upgraded to current state standards.

Cost: $272,686 spent on project

Timetable: This 3-year project is being completed in fall 1997.

Level of commitment: The Forest remained committed to completing this project, despite encountering logistical problems and cost overruns.

Expected benefits of measure to steelhead: The increased attraction flow at the base of the fish ladder should help steelhead find the fish ladder, so they can continue migrating upstream to spawning areas. The fish ladder now competes with the flows going over the dam, as well as a false attractant flow from a wasteflow pipe.

Phase 2 Measure: Maintenance of Hemlock Dam (Funding of short-term and long-term maintenance is still in question)

Phase 2 Measure: Remove dam or establish a new channel through the reservoir in conjunction with a recreational pond

Factors for decline the measure will improve:

A-I temperature
A-II sediment
B-III substrate
C-II adult steelhead upstream passage

North Fork Lewis River (WRIA 27)

North Fork Lewis complex of hydroelectric projects

Project Description

The Lewis River drains a watershed of approximately 731 square miles and enters the Columbia River near Woodland, Washington. There are four major hydroelectric projects located on the mainstem North Fork Lewis River. These are (from downstream to upstream) Merwin, Yale, Swift No. 2, and Swift No. 1. Merwin, Yale and Swift No. 1 projects are owned and operated by PacifiCorp. Swift No. 2 is owned by Cowlitz Public Utility District (Cowlitz PUD) and operated by PacifiCorp.

Merwin dam, constructed in 1929-1931 is a 313 ft. high concrete arch with a crest elevation of 240 feet (msl). The reservoir is 14.5 miles long with a storage capacity of 422,000 acre-feet (at 239.5 ft-msl). The project has 3 Francis-type turbines with an installed capacity of 135 megawatts (mW).

Yale dam was completed in 1953 and consists of a 323 ft. high earth fill dam with a crest elevation of 509 ft-msl. The reservoir is 10 miles long and has a storage capacity of 402,000 ac-ft. The Yale powerhouse has 2 Francis-type turbines with a current installed capacity of 134 mW.

Swift No. 1, constructed in 1956-1958, is a 512 ft. high earth fill dam with a crest elevation of 1012 ft-msl. The reservoir has a length of 12 miles and a storage capacity of 755,500 ac-ft. The project powerhouse has 3 Francis-type turbines with an installed capacity of 268 mW.

Swift No. 2 is a companion powerhouse to Swift No. 1 which utilizes tailrace water from No. 1 via a 3.5 mile long canal to the No. 2 intake. The powerhouse has 2 Francis-type turbines with an installed capacity of 70 mW.

Merwin Dam blocks anadromous fish migration. There is no passage around the complex of dams. Merwin and the other projects upstream from it inundate a large number of stream miles, both mainstem and tributary, that previously supported steelhead. Blockage of steelhead passage has also blocked salmon passage, resulting in reduction of salmon carcass input which previously contributed to stream nutrients and productivity. Habitat heterogeneity of headwaters is lost to steelhead, reducing refuge when mainstem conditions are unfavorable. Bypass flows in Swift No. 2 are unfavorable to fish if passage were achieved. Predators thrive in Merwin reservoir, which is a poor environment for steelhead migration. Downstream passage facilities for steelhead smolts are not favorable for survival.

Table 4.	Factors for Decline	Merwin	Yale	Swift 1	Swift 2
A-I	**temperature**				
A-II	**sediment**				
A-III	**dissolved oxygen**				
A-IV	**elevated total dissolved gas**	**only during rare spills**			
A-V	**compromised biological conditions**	+			
A-VIII	**reductions in salmon carcass input**	+	+	+	+
B-I	**riparian**				+
B-II	**channel morphology**				
B-III	**substrate**				
B-IV	**instream roughness**				
B-VI	**wetlands**				
B-VII	**habitat elimination**	+	+	+	
C-I	**streamflows**				+
C-II	**passage**	+	+	+	
C-III	**screening**	+	+	+	
C-IV	**reservoir inundation**	+	+	+	
D-I	**harvest impacts**				
D-II	**genetic loss**	**?**	**?**	**?**	
D-III	**predation**	+			

The table below lists North Fork Lewis River hydroelectric projects and their effects on steelhead. Numbers in pairs indicate degree of existing impact (low-high), followed by potential for restoration, improvement, or enhancement.

Table 5						
	Downstream from Merwin powerhouse	**Merwin Dam**	**reservoirs**	**dams above Merwin**	**Swift #2 bypass**	**above Swift Reservoir**
Passage upstream: adults	low, medium	high, medium	medium, low	high, medium	high, medium	
Passage upstream: salmon for nutrients	low, high	high, medium	high, low	high, high	high, high	high, high
Passage downstream: smolts	low, low	high, medium	low, medium	high, medium		
Passage downstream: kelts	low, low	high, medium	low, medium	high, medium		
Screening		low, medium		low, medium		
Instream flows	low, low	low, low		low, low	medium, high	
Ramping	medium, low	medium, low			low, low	
Sediment transport	medium, low	medium, low	medium, low	medium, low	low, low	
Channel maintenance: woody debris	medium, medium		low, low		low, low	
Channel maintenance: armoring	low, low		low, low		medium, low	low, low
Channel maintenance: riparian	low, low	low, low	low, low		medium, medium	low, low
Habitat inundation		high, low	high, low	high, low		
Water quality: temperature	low, low	low, low	low, low	low, low	low, low	
Water quality: dissolved oxygen	low, low	low, low	low, low	low, low	low, low	
Water quality:	medium,	medium,	low, low	medium,	medium,	

gas super-saturation	medium	medium		medium	medium	
Hatchery mitigation: genetic	medium, medium					
Hatchery mitigation: disease	medium, medium					
Hatchery mitigation: toxics	low, medium					

Lewis River Steelhead Enhancements : PacifiCorp

Proposed Measures

Phase 1 Measure: Assist with lower Lewis River tributary enhancement projects currently proposed by the U.S. Forest Service and the Lewis River fish enhancement group.

PacifiCorp to provide partial funding, technical assistance, and large woody material from Swift reservoir for habitat restoration projects on key tributaries to the Lewis River including Cedar Creek, Colvin Creek and the East Fork Lewis River.

The US Forest Service (USFS) is currently conducting habitat restoration efforts on the East Fork Lewis River for the benefit of all life stages of steelhead. The Lower Lewis River Fish Enhancement Group (Fish First) has developed and is implementing a Cedar Creek restoration project for the benefit of salmonids. PacifiCorp has contributed some technical assistance to the Cedar Creek project and assisted USFS with securing large woody material from Swift Reservoir for the enhancement efforts. PacifiCorp proposes to continue its participation and to commit funding to aid in the completion of the Cedar Creek and East Fork Lewis River projects. In addition, PacifiCorp will continue providing field assistance to WDFW for the purpose of conducting steelhead spawning surveys on Cedar Creek and provide for efforts at Lewis River hatchery to mark and hold spawned out carcasses for nutrient enrichment programs in the basin.

Phase 1 Measure: PacifiCorp to fund fish marking program and creel survey of lower Lewis River steelhead to determine hatchery steelhead contribution and impact to wild steelhead

PacifiCorp will fund a Merwin hatchery evaluation to determine the effect the hatchery produced winter and summer steelhead are having on the wild Lewis River steelhead component.

Merwin trout hatchery was constructed as required in the Merwin license to mitigate for losses incurred by the native Lewis River steelhead populations. Beginning immediately, PacifiCorp will fund an evaluation of the effect of hatchery produced steelhead on the wild steelhead component. In order to accomplish this, steelhead produced at Merwin hatchery that were marked with an identifying coded wire tag will be evaluated in a creel survey beginning fall 1997 and continuing through fall of 2000. In addition, hatchery released smolts will be captured in the mainstem to determine river exit timing and interaction with other wild salmonids including steelhead, spring and fall chinook, and cutthroat.

Phase 1 Measure: PacifiCorp to review current flow regime for Merwin Dam with agencies to determine effects on all steelhead life stages

As part of Article 49 of the current Merwin license, PacifiCorp and the Washington Department of Fish and Wildlife (WDFW) conducted a 10 year evaluation of Merwin flows to establish minimum flow regimes for the benefit of the Lewis River wild fall chinook population. The current flow schedule is as follows:

Table 6

Period	1983 License	1993 Revision
December 8-March 1	1500	1500
March	2700	2000
	2700 to 1000	2000 to 1000
April	2700	2700
	2700 to 1300	2700 to 1300
May	2700	2700
	2700 to 1650	2700 to 1650
June	2500	2700
	Natural or 1650	Natural or 1650
July 1 - July 15	2000	2000
	Natural or 1200	Natural or 1200
July 16 - July 31	1500	1500
	Natural or 1200	Natural or 1200
August 1 - October 15	1200	1200
October 16 - October 31	2700	2700
November 1 - November 15	Natural + 2000	Natural + 2000
	or 4200	or 4200
November 16 - December 7	Natural + 2000	Natural + 2000
	or 5400	or 5400

These established flows may or may not benefit steelhead. PacifiCorp will consult with agencies to determine the effects of the current flow regime on steelhead in the North Fork Lewis River.

Phase 2 Measure: PacifiCorp to study reservoir passage criteria for downstream migrating smolts

PacifiCorp is committed to participating with other regional utilities in implementing a long-term study to determine reservoir passage criteria for downstream migrating smolts and to establish uniform reservoir passage at all reservoirs in the Pacific Northwest.

Phase 1 Measure: Complete Lewis River Watershed Analysis by May 2001.

PacifiCorp is currently conducting a basin-wide watershed analysis of the Lewis River watershed. The purpose of the watershed analysis is to identify resource issues, list potential impacts of PacifiCorp's projects and other watershed activities, determine key questions related to each resource and ultimately identify potential enhancements. PacifiCorp has solicited the involvement of agencies, tribes and environmental groups to participate in the scoping, study design and review, technical work groups and development of enhancements. Finally, a settlement agreement will be developed and agreed upon by participating parties. The process is currently in the scoping phase with studies anticipated to begin in March or April 1998. PacifiCorp commits to completion of the process and development of a settlement agreement for it's Lewis River hydroelectric project enhancements.

Phase 2 Measure: Implement Watershed Analysis enhancement measures upon completion of the Lewis River settlement agreement.

Numerous potential enhancement measures are likely to result from the watershed analysis process. However, PacifiCorp does not want to circumvent the watershed analysis process and commit to enhancement measures before participating parties have had a chance to review all possible measures and develop the settlement agreement. In light of this and upon completion of the settlement agreement, PacifiCorp will implement, without delay, all agreed upon measures. Several potential enhancement measures have already been suggested and will be evaluated during the process. Several critical measures that directly pertain to conservation of steelhead and other designated species in the Lewis River basin will be given priority. A partial list of these potential measures follows:

- Gravel enhancement downstream of Merwin dam
- Improve connectivity for aquatic species and increase overall ecological integrity and biological diversity of the watershed
- Modify turbines to reduce gas supersaturation at tailraces
- Manage instream flows to reduce adverse impacts of changes to water quality
- Manage hatcheries to reduce impacts on water quality
- Adjust instream flows to bypass or diverted reaches to modify amount of water routed through natural stream channels
- Use only wild fish, randomly selected from throughout the population to restore populations
- Adjust ramping rates to minimize effects on aquatic biota
- Participate in a joint funding effort to purchase and protect Eagle Island
- Numerous other potential enhancements have been identified in the watershed analysis scoping process and will be evaluated. If during the watershed analysis process, interim measures are identified that could be implemented prior to completion of the entire process, then PacifiCorp will consider early implementation of those measures.

Cowlitz River (WRIA 26)

Cowlitz River complex of hydroelectric projects

Location: Series of dams on Cowlitz River
Owners: Cowlitz Hydroelectric Project (FERC 2016) Tacoma Public Utilities (TPU)
Barrier Dam
Mayfield Dam
Mossyrock Dam
Cowlitz Falls Dam (FERC 2833) Lewis Co PUD

Description of projects: Barrier Dam is the downstream-most dam in this complex. Although it blocks anadromous fish migration, the Barrier Dam was built to block fish and direct them to mitigation facilities. Mayfield Dam, approximately 2 miles upstream from Barrier Dam, was originally built with fish passage, but fish passage was abandoned, except for some effort to continue to transport fish that are trapped and hauled around the complex of dams. Mayfield, Mossyrock, and Cowlitz Falls dams inundate a large number of stream miles, both mainstem and tributary, that previously supported steelhead. Blockage of steelhead passage has also blocked salmon passage, resulting in reduction of salmon carcass input which previously contributed to stream nutrients and productivity. Habitat heterogeneity of headwaters is lost to steelhead, reducing refuge when mainstem conditions are unfavorable. Predators thrive in the reservoirs, which are poor environments for steelhead migration. Downstream passage facilities for steelhead smolts are not favorable for survival.

Table 7					
Factors of Decline		Barrier	Mayfield	Mossyrock	Cowlitz Falls
A-I	**temperature**		+	+	+
A-II	**sediment**		+	+	+
A-III	**dissolved oxygen**				
A-IV	**elevated total dissolved gas**		+		
A-V	**compromised biological conditions**	+	+	+	**?**
A-VII	**toxic substances**	+			
A-VIII	**reductions in salmon carcass input**	+	+	+	+
B-I	**riparian**	+	+	+	+
B-II	**channel morphology**		+	+	+
B-III	**substrate**		+	+	+
B-IV	**instream roughness**				
B-VI	**wetlands**				
B-VII	**habitat elimination**	+	+	+	+
C-I	**streamflows**	**?**			
C-II	**passage**	+	+	+	+
C-III	**screening**		+	+	
C-IV	**reservoir inundation**		+	+	+
D-I	**harvest impacts**	**L**			+
D-II	**genetic loss**	**L**	**?**	**?**	
D-III	**predation**	**L**	**L**		+

Cowlitz River hydroelectric projects and their effects on steelhead. Numbers in pairs indicate degree of existing impact (low - high), followed by potential for restoration. For example, “low, high” indicates that the impact is low and can be mitigated to a high degree. A rating of “high, low” indicates a severe impact with little prospect for restoration. It is assumed that the projects remain in operation when potential restoration is rated. A rating of “high, high” indicates that a severe impact can be mitigated to a high degree.

Table 8						
	Downstream from barrier dam	Barrier Dam	Mayfield to Barrier Dam	Mayfield, Mossyrock, & Cowlitz Falls dams	Reservoirs	Above Cowlitz Falls
Passage upstream: adults	low, low	high, high	low, low	medium, medium	medium, low	high, high
Passage upstream: salmon for nutrients	low, low		high, low		high, low	high, medium
Passage downstream: smolts	low, low	medium, medium		high, medium	high, low	low, low
Passage downstream: kelts	low, low	medium, medium		high, medium	high, low	low, low
Screening				medium, medium		
Instream flow	low, high		low, high			
Ramping	low, high	low, high				
Sediment transport	medium, low		medium, low		medium, low	low, low
Channel maintenance: woody debris	medium, medium		medium, medium			medium, medium
Channel maintenance: armoring	medium, medium		medium, medium			
Channel maintenance: riparian	medium, medium		medium, medium		medium, medium	medium, medium
Habitat inundation					high, low	
Water quality: temperature	low, medium		low, medium		medium, low	
Water quality: dissolved oxygen	low, medium		low, medium			
Water quality: gas super-saturation	low, medium		low, medium			
Hatchery mitigation: genetic	medium, medium		medium, medium			medium, medium
Hatchery mitigation: disease	high, medium		medium			low, low
Hatchery mitigation: toxics	medium, high		medium, high			

Phase 1 Measure: Cowlitz Falls and Cowlitz Basin anadromous salmonid restoration program.

The purpose of this program is to restore anadromous fish runs to the upper Cowlitz River, above the Cowlitz Falls Dam, as well as protection of wild, native, and naturally reproducing resident fish and hatchery populations. This restoration, is in part the result of the September, 1991 Settlement Agreement between the Bonneville Power Administration (BPA) and the

Friends of the Cowlitz (FOC). The Plan includes programs to reintroduce anadromous salmonids for restoration and for providing recreational harvest opportunities. The new facility allows juvenile salmonids to be collected at the Cowlitz Falls Project and transported around the two lower River reservoirs to be released and continue their migration to the ocean. Additional detail on the Cowlitz Falls restoration plan is provided in Appendix 7.

A primary goal of steelhead restoration effort is to establish a self sustaining run.

The Cowlitz Falls anadromous fish restoration program includes three phases, a smolt rearing (WDFW enhancement), a fry/fingerling outplanting program (outplanting/natural rearing) and an evaluation of the fish passage facility (FGE evaluation). A fourth phase, natural reproduction, will replace some portion of the outplanting program dependent on environmental conditions and management decisions.

Strategies:

1. Short term: Supplement steelhead production with Cowlitz River late winter steelhead stock to seed the upper watershed for anadromous reintroduction and continue to provide hatchery origin resident and anadromous fish for recreational fisheries.

2. Long term: Establish self sustaining populations of wild origin trout, steelhead, and potentially salmon in balance within the capacity of the watershed.

The new goal for the Cowlitz Falls reintroduction program was modified to reflect WDFW's goals as stated in the draft Wild Salmonid Policy and reads as follows:

> "…to establish self-sustaining wild trout, steelhead, and salmon where they historically occurred, in balance with the capacity of the watershed and to provide sustainable recreational fisheries benefits above Cowlitz Falls Dam."

During the first four years, the steelhead effort focused on scatter planting steelhead fry in an attempt to re-establish natural production. Smolts collected at the Cowlitz Falls project will be transported to the Cowlitz Salmon Hatchery, allowed to recover in stress relief ponds and then continue their seaward migration. Returning adults from this program are for reintroduction purposes and will be managed similar to State wild salmonid policy, minimizing harvest to allow escapement and wild spawning.

In addition to the restoration program, the plan calls for the release of up to 100,000 right ventrally clipped late winter steelhead smolts to provide for a recreational fishery. These fish are reared at the Cowlitz Steelhead hatchery to presmolt and are then transported to net pens in the upper watershed for approximately eight weeks to become smolts and imprint on the upper watershed. In April and May about half the smolts are transported and released below the barrier dam at Salkum. The remaining half are released in the upper watershed, allowed to migrate downstream to the Cowlitz Falls fish facility where the smolts are collected, and transported to the stress relief ponds at the Cowlitz Salmon Hatchery. The adults should return to the Cowlitz Salmon Hatchery from mid-March to mid-June as discussed previously. This program will serve two purposes: (1) it provides

for a recreational harvest in the upper watershed and (2) fish not caught will provide additional spawners for the restoration effort. The first return of late winter adult steelhead for recreational harvest is expected in 1997.

The first restoration fish, 350,000 late winter steelhead fry were scatter planted throughout the upper Cowlitz and Cispus River Basins in September 1994, followed by similar efforts, including releases of spring chinook and coho, in 1995 and 1996. These efforts along with the State's updated "Cowlitz Falls Anadromous Reintroduction Program," support from the hatcheries for donor stocks, and the future direction envisioned in WDFW's Wild Salmonid Policy provide an opportunity to restore runs of anadromous fish to anadromous habitat that is not currently being used. Late winter run steelhead of Cowlitz River origin are being used because the best available data indicates that it most closely resembles the historical run of steelhead in the Cowlitz previous to hatchery introductions

A critical component of the anadromous restoration program and its evaluation is the collection of juvenile salmonids at the Cowlitz Falls Fish Collection Facility. This fish facility incorporates a state of the art surface collection system, transport flumes, raceways and handling facility. This system is designed around a trap and haul program that requires upstream and downstream transport of both adult and juvenile salmonids respectively. Biologists monitor and evaluate the reintroduction program and the new surface collection system, completed in December 1996 and turned over to BPA/LCPUD in January 1997. Preliminary evaluations in 1996 and 1997 indicate that fish guidance efficiency (FGE) for steelhead may approach 75%. The preliminary FGE estimates for coho were less than 50%. The first FGE estimates for spring chinook were obtained this season and appear to be less than 50%. However, modifications to increase attraction flow have recently been completed and protocols to refine FGE tests are being developed for 1998.

All adult steelhead which originate from this program and return to the hatchery will be collected and sorted at the Cowlitz Salmon Hatchery adult facility and then transported to the upper watershed. All juveniles for the restoration efforts are supplied by the hatchery until natural reproduction begins to replace some of the hatchery component. TPU has supplied the fish and transportation for the reintroduction effort and has agreed to provide downstream transportation when the need arises.

Phase 1 Measure: Multi-party planning for relicense of Cowlitz Project is addressing steelhead along with other fish and wildlife issues.

Part of this effort employs the Ecosystem Diagnostic and Treatment (EDT) process to attempt to evaluate what potential mitigation measures will provide the greatest benefit to anadromous fish production in the basin. These potential mitigation measures could be implemented by TPU as mitigation during FERC relicensing. The EDT has used fall

chinook salmon as the diagnostic species, which reduces the value for steelhead restoration somewhat because of significantly different life histories and habitat use by these two species. Steelhead might be brought into the EDT process. Outcomes and benefits to steelhead are undetermined.

Timetable is uncertain, given lack of predictability of FERC process, which has been indecisive for over two decades on another Washington project.

Phase 2 Measure: Implementation of plans developed in Phase 1.

Timetable is uncertain, given lack of predictability of FERC process, which has been indecisive for over two decades on another Washington project.

Mill Creek Hydroelectric (FERC 4949)

The Mill Creek project was built in the early 1980s and is operated by Lewis County PUD. It was built very near or at the upstream limit to anadromous fish migration. It operates as a run-of-the-river, non-storage project. Instream flows between the diversion dam and the powerhouse are less than optimum and less than natural. Construction removed much vegetation from the riparian areas, but presence of project might have saved some riparian vegetation compared to subdivision now being built around it.

Factors for decline:

A-I	temperature	?
A-II	sediment	+
A-III	dissolved oxygen	?
A-IV	elevated total dissolved gas	?
B-I	riparian	+
B-II	channel morphology	+
B-III	substrate	+
B-IV	instream roughness	+
B-VI	wetlands	?
C-I	streamflows	+

Toutle River Sediment Retention Dam

The North Fork Toutle River Sediment Retention Structure Project (SRS) is operated by the Army Corps of Engineers (COE) to prevent coarse sediment from the Mt. St. Helens eruption from depositing in the lower watershed, including the lower Cowlitz River, to reduce flood risk. The SRS has filled to spillway level with coarse bedloads. Coarse sediments are expected to flow over the SRS spillway during high flows.

Once coarse sands begin passing the structure and sediment levels behind the SRS reach the upper levels of SRS bypass conduits, the conduits are to be closed and Phase 2 management is to commence. At Phase 2 the highest conduit level may be opened periodically for SRS maintenance and can provide spillway bypass during low flows. Phase 2 operation is "run-of-river" and basin hydrology is to govern sediment transfer to the lower watershed.

Lower Cowlitz River anadromous fish are impacted by operations of the SRS on the North Fork Toutle River and by the City of Tacoma Cowlitz Hydroelectric Project (FERC 2016, RM 50). The sediments supplied by the Toutle River are not flushed out by the flows released from Tacoma's project. Tacoma has reduced channel maintenance flows 30% relative to pre- project flow conditions.

Self-sustaining populations of wild salmonids have been restored to the upper river after volcano-caused declines. Phase I fish mitigation included WDFW's operation of the Fish Collection Facility (FCF) just downstream of the SRS. The FCF has met fish passage objectives and may be phased out as SRS Phase 2 develops. WDFW may continue some FCF operations (e.g., collect and separate fish). The SRS spillway was designed, and has been maintained, to be as fish "friendly" as possible. The spillway may be made fish passable with little modification or maintenance required.

Smolt survival decreases as North Fork Toutle River suspended sediments (NFSS) concentration increases. NFSS are abrasive to fish gill tissue and caused acute and delayed salmonid mortality (Stober et al. 1983). Smolts outmigrating later, in April - May, survive to return in greater numbers than early migrating smolts. NFSS loadings in the river are at the highest levels in March and low in May. Most wild salmonid smolts outmigrate in late April through May.

The COE repaired 1996 flood damage to the SRS spillway (erosion to the spillway mouth and ramp) beginning in May 1997 without notifying WDFW of plans, resulting in a heavy sediment load (including coarse sand) to the lower river, where it was deposited because of low flow. The sediment behind the SRS is still being eroded downstream and bedload sediments have deposited throughout the FCF area, precluding FCF operations.

Wild cutthroat and summer steelhead trout are blocked now, and winter steelhead, coho and chinook could be blocked as well, later in the fall and winter. Adult salmonids may not enter the North Fork Toutle River until SRS repair-generated suspended sediment levels in the river decrease with SRS bypass conduit closure this September. The FCF had been consistently successful in passing fish upstream in the years previous to the COE spillway repair.

Factors of decline:

A-II	sediment	+
B-I	riparian	+

B-II	channel morphology	+
B-III	substrate	+
B-IV	instream roughness	+
C-II	passage	+

Possible measure:

Managing the SRS to reduce NFSS in the lower river during the most fish-sensitive times of the year would entail amending the SRSOM, which can only be done by Congress. Amendment of the SRSOM would require a request by WDFW to Congress. The upper conduits would be used to maintain a sediment sump behind the SRS during the high flow season, then the conduits would be closed when flows drop in the spring. In this manner sediments could be trapped and removed from suspension during the juvenile outmigration season in the lower Toutle and Cowlitz Rivers. This sediment sump could be maintained through the spring, summer, and early fall by using high flows to flush sediments from the sump and out of the lower Toutle River. Adult and juvenile salmonid passage and rearing conditions in the lower river would be improved. Cowlitz River flow releases from Mayfield Dam could be regulated in concert with Toutle River high flows to increase fine sediment transport from the confluence of these rivers to the Columbia River.

Monitoring with Standard Field Bioassay (LC50, 96 hour) should provide guidance for SRS sediment management in order to protect upper North Fork Toutle and Lower Cowlitz River wild salmonid outmigrants.

Possible measure:

The FCF should be put back on line as a conservation measure.

Other Dams

The Washington State Dam Inventory indicates that there are numerous other dams and impoundment structures located within the LCSCI area. Some of these are offstream (e.g., sewage lagoons and waste ponds), but a number are located on tributaries. Information on the effect these structures have on steelhead is lacking. Evaluation of these projects would benefit from an analysis and map which illustrates the location of these dams in relation to steelhead habitats.

Columbia River mainstem

Bonneville Dam

Bonneville Dam on the mainstem Columbia River creates a major adverse impact to steelhead in the upper part of the LCSCI area, including the Wind River in Washington and the Hood River in Oregon. Bonneville Dam affects steelhead by hindering passage upstream and downstream, creating a situation for predation, and causing high levels of dissolved gas below the dam.

Table 9		
Factor for decline	**Possible mitigation measures**	**Prospects for success**
Downstream passage for juvenile steelhead (C-II)	Smolt screening of intakes	Difficult, but improving, and juvenile steelhead are the easiest of anadromous salmonids to pass downstream
Upstream passage of adult steelhead (C-II)	Fish ladder design improvement, including location and attraction flow	?
Compromised biological conditions (A-V)	Decrease area suitable for predators and predation through flow and stage management above Bonneville Dam	?
Predation (D-III)	Squawfish control	Significant promise has been indicated by initial evaluations
Gas supersaturation (A-IV)	Spillway modification (flip lip)	?

Appendix A1. Watershed areas above selected stream gauges.

Drainage	Subbasin	Watershed area (mi^2)	Project Watershed	
Cowlitz	all	USGS gage #14243000	2,238	
	Toutle	USGS gage #1424580	496	
	Sediment Retention Structure	USGS gage #14240525	175	
	Above Toutle		1,740	
	Above Mayfield Dam	USGS gage #14240535 (or #142380)	1,400	(80% above Toutle) (63% total basin)
Kalama	all	S33T7NR1W	201	
Lewis	N. Fk.	USGS Gage #14220500	731	
	E. Fk.	USGS gage #14222500	125	
	Cedar Ck.	S11T5NR2E	41	
Salmon Ck	all	S26T3NR1E	77	
Washougal	all	S27T2NR4E	108	
Wind	all	S21T3NR8E	225	